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The new normal: The status quo of AI adoption in SMEs

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ABSTRACT

The recent surge in the adoption of artificial intelligence (AI) by small and medium-sized enterprises (SMEs) has garnered significant research attention. However, the existing literature reveals a fragmented landscape that hinders our understanding of how SMEs use AI. We address this through a systematic literature review wherein we analyze 106 peer-reviewed articles on AI adoption in SMEs and categorize states and trends into eight clusters: (1) compatibility, (2) infrastructure, (3) knowledge, (4) resources, (5) culture, (6) competition, (7) regulation, and (8) ecosystem: according to the technology–organization–environment model. Our research provides valuable insights and identifies significant gaps in existing literature, notably overlooking trends identification as a pivotal driver and neglecting legal requirements. Our study clarifies AI implementation within SMEs, offering a holistic and theoretically grounded perspective to empower researchers and practitioners to facilitate more effective adoption and application of AI within the SME sector.

KEYWORDS

AI; artificial intelligence; small business; SME; technology

Introduction

Within the dynamic landscape of science and technology, artificial intelligence (AI) has emerged as a catalyst reshaping our interactions with technology, our problem-solving methods, and even our comprehension of intelligence itself (Giuggioli & Pellegrini, 2023). Despite the vast potential of AI, its integration within small and medium-sized enterprises (SMEs) faces considerable hurdles, notably the challenges of change management (Nagy et al., 2023). Overcoming these challenges and fostering AI adoption is imperative for SMEs to thrive (Lemos et al., 2022).

Critically, boosting AI use within SMEs requires navigating the complexities inherent in identifying suitable AI technologies and applying

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them across an array of organizational functions and deployment scenarios (Hansen & Bøgh, 2021). The literature on applying AI in SMEs, while abundant, often lacks coherence and comprehensiveness (bin Ahmad et al., 2019; Giuggioli & Pellegrini, 2023; Treiblmaier, 2018). This is unfortunate, as AI adoption by SMEs has substantial potential benefits ranging from productivity enhancements to cost reductions to improved employee experiences (Chaudhuri et al., 2022).

Failure to embrace AI could have dire consequences for SMEs, including lost competitiveness and market share, diminished economic influence, and reduced employment opportunities (Baabdullah et al., 2021). While AI adoption strategies vary, they typically involve increasing investments, automating processes, and upgrading systems and technologies to remain competitive (Hansen & Bøgh, 2021). It is essential to note, however, that overly complex AI applications may not be feasible for SMEs because of their cost and complexity (Moeuf et al., 2020).

Various theories exist to explain technology adoption within various contexts (Orr, 2003; Venkatesh et al., 2003). AI implementation within the SME context requires a theory that can comprehensively analyze its complexity and versatility (Khan et al., 2021). This study employs the technology—organization—environment (TOE) model (Tornatzky & Fleischer, 1990) to systematically analyze the current state of the literature. This framework offers valuable insights into the internal and external factors influencing technology adoption decisions within organizational contexts (Hossain & Quaddus, 2012).

The TOE model allows a structured examination of the dynamics influencing AI adoption in SMEs by considering factors such as technological readiness, organizational capabilities, and environmental influences (El-Haddadeh, 2020). Against this backdrop, our study provides a structured overview of AI research within the SME sector, identifying challenges, facilitators, opportunities, and implementation domains. Employing a systematic literature review (SLR), we integrate existing research to offer valuable insights for researchers and practitioners. Through this consolidation, we aim to advance AI adoption in SMEs and contribute to the existing body of knowledge in this field.

The study is structured as follows. The theoretical background for defining AI within the context of implementation within SMEs using the TOE model is presented; our research methods are described; followed by the results; and a comparative analysis of our findings with previous research, offering academic and practical recommendations. We identify the limitations of the research and avenues for future research, which also presents the conclusions.

Theoretical foundation of artificial intelligence and its implementation requirements in small and medium-sized enterprises

Definition of artificial intelligence

AI has rapidly transformed the world and impacted all areas of business functionality (Budhwar et al., 2023). It encompasses three generations: (1) artificial narrow intelligence, designed for specific tasks, (2) artificial general intelligence, capable of independently solving a wide range of problems, and (3) artificial superintelligence, anticipated to possess scientific creativity along with social and technical skills (Deepa et al., 2024). AI, often referred to as machine-generated intelligence, empowers machines to perform tasks and tackle complex challenges that have traditionally exceeded human cognitive capabilities (Giuggioli & Pellegrini, 2023). The technical maturity and market readiness of AI-related methods and processes are continually improving, reflecting the high-level engineering and research activity within this domain. Machine learning and deep learning, often synonymous with AI, describe how computers can learn patterns based on input data. AI also comprises various vital subdomains, such as voice recognition, image identification, natural language processing, expert systems, neural networks, planning, robotics, and intelligent agents (Whitson, 2024). AI is characterized by its multidisciplinary nature (Hermann, 2023) and integration with cutting-edge technologies (Hansen & Bøgh, 2021). Moreover, AI plays a crucial role in the Internet of Things (IoT), which constitutes an interconnected network of physical devices capable of communication and remote monitoring (Ashton, 2009). AI encompasses various methods, including machine learning, an analytical approach applicable to data from IoT devices (Hansen & Bøgh, 2021). AI processes vast volumes of IoT data to generate actionable insights, bridging the software languages enforced by IoT devices (bin Ahmad et al., 2019). In addition, AI enhances augmented reality (AR), a human–computer interaction system that merges real and virtual 3D objects in real time (Azuma et al., 2001). AI plays a critical role in the advancement of manufacturing assembly robots, enabling them to work more efficiently, safely, and intelligently and improving processing accuracy and effectiveness (Soori et al., 2023). Last, AI intersects with blockchain, a distributed ledger technology that securely and transparently records digital assets (Treiblmaier, 2018). This study focuses on AI-related technologies from a business perspective, as AI has shifted from a futuristic concept understood by a select group of experts to become an affordable mainstream solution transcending its application solely to large enterprises (Giuggioli & Pellegrini, 2023).

Factors influencing the adoption of artificial intelligence in small and medium-sized enterprises

The definition of SMEs varies by country (Ardic et al., 2011). SMEs are defined by the EU Commission as organizations with fewer than 250 employees and revenues below EUR 50 million per year (European Commission, n.d.). Meanwhile, in the United States, the Small Business Administration categorizes small businesses based on ownership structure, employee count, earnings, and industry (United States Small Business Administration, n.d.). For example, in production, an SME generally consists of 500 or fewer employees. The Internal Revenue Service defines small businesses as entities with assets of $10 million or less, while those surpassing this threshold are considered large businesses (Internal Revenue Service, 2023). Compared with larger corporations, SMEs often face limitations due to constrained human and financial resources (Dörr et al., 2023). However, new technologies are anticipated to profoundly affect SMEs and society at large, which could ameliorate some constraints encountered by SMEs (Ameen et al., 2022). In recent years, the emergence of AI-related technologies such as blockchain, IoT, and social media have affected organizational processes and are poised to replace traditional methods in SMEs (Giuggioli & Pellegrini, 2023). While studies show that implementing AI technologies offers new market opportunities and process development potential for SMEs (Chatterjee et al., 2022), a recent Deloitte report indicates a discrepancy—94% of business leaders believe that AI will be crucial for success in the next five years, but that its implementation will lead to delayed outcomes. Consequently, willingness to invest in AI decreased from 85% in 2021 to 76% in the surveyed group (Mittal et al., 2022).

Several determinants influence SMEs' adoption of AI technologies. Compatibility, readiness, efficiency improvement, and time savings are key factors that directly and indirectly affect AI adoption through accounting automation (Devkota et al., 2022; Lee & Tajudeen, 2020). Chatterjee et al. (2022) emphasize the significance of perceived usefulness, ease of use, willingness to change, and strategic planning for successful applications of AI technology. Dörr et al. (2023) identify various determinants for successful digital transformation, encompassing executive management, strategy, employees, culture, data management, and more. Korherr et al. (2022) outline critical factors for transitioning to analytics-based decision-making involving management behavior, infrastructure, organization, and culture. Importantly, AI offers many opportunities to SMEs. Empirical studies reveal that the application of intelligent communication systems leads to a higher degree of customer experience and satisfaction, thereby providing a higher degree of loyalty and opening new market opportunities due to a higher level of customer data (Rizomyliotis et al., 2022). Furthermore, AI enhances SME decision-making for complex analyses where SMEs deal with large data and provide

customers with bespoke services and products. In addition, SMEs can achieve enhanced efficiency through automated processes (Hunter, 2019). An increase in organizational innovativeness and capabilities leads to a corresponding increase in the adoption of AI technologies by SMEs. These findings underscore the importance of fostering an environment conducive to SME innovation coupled with the development of relevant capabilities. This suggests that SMEs that cultivate a culture of innovation and possess the necessary capabilities are more likely to embrace and effectively use AI technologies (El-Haddadeh, 2020). Despite the market opportunities offered by digital technologies, SMEs encounter challenges when adopting them (Ameen et al., 2022). SMEs are typically unable to compete with dynamic market challenges. The limited availability of technologies and resources constrains SMEs from flourishing and becoming leaders and drivers of economic growth in light of complex circumstances within the global environment (Chatterjee et al., 2022). Nonetheless, SMEs play a pivotal role in the international economy. Recognizing this, the EU aims to enhance SMEs' business activities and ensure their alignment with updated technologies because their international competitiveness influences economic stability (Hansen & Bøgh, 2021).

Technology–organization–environment model

The TOE framework was essentially coined by Tornatzky et al. (1983) to exhaustively explicate behavioral intentions and the implementation of innovation at the firm level (Nguyen et al., 2022). The literature on SME adoption of AI technologies encompasses various clusters, each delineating AI adaptiveness within an organizational context. To provide a structured analysis and delineate avenues for further research, we employ the TOE framework, a well-established theoretical model present in recent academic literature (El-Haddadeh, 2020; Nguyen et al., 2022; Tornatzky et al., 1983). Using a theoretical foundation to study the adoption of digital innovations in organizations necessitates careful attention to the factors that influence the adoption process. In this context, existing literature has confirmed that the TOE framework is suitable for analyzing the specific innovation dynamics affecting organizational adoption, particularly in the case of technical innovation dynamics (El-Haddadeh, 2020). Understanding the various factors influencing organizational adoption of AI can link the adoption of new technologies to a company's technological, organizational, and environmental characteristics. This linkage provides scholars and decision-makers with a broader perspective on the factors affecting AI adoption within the SME context (Khan et al., 2021). While frameworks like the technology acceptance model and the unified theory of acceptance and use of technology focus on individual acceptance decisions, the complexity and scale of organizational technologies often necessitate a more robust framework. The TOE framework

delineates factors influenced by an organization's introduction of information technology from three contextual perspectives: environmental, technological, and organizational (Tornatzky & Fleischer, 1990).

The environmental context encompasses the external conditions in which companies operate, such as industry dynamics, competitors, and governmental influence. The technological context comprises internal and external technologies faced by the organization, encompassing market-available technologies and those existing within the organization. Last, the organizational context delineates the attributes and resources of the firm, including size, hierarchy, and human resources (Tornatzky et al., 1983).

Various studies have applied the TOE model in various ways ranging from cost-setting, security concerns, and management support as independent variables to integrating organizational factors with theories of innovation diffusion and technology acceptance. These studies have contributed to our understanding of the factors influencing AI adoption in SMEs (Lee & Lee, 2014). Each study highlights how the three elements—technology, organization, and environment—affect how a firm identifies the need for, searches for, and adopts new technology. SMEs must carefully navigate the adoption of innovative and disruptive technologies due to the significant impact such changes can have on technological, organizational, and environmental dynamics (Khan et al., 2021).

However, empirical studies testing the TOE framework have used slightly different factors within the technological, organizational, and environmental contexts. Researchers agree with Tornatzky and Fleischer (1990) that these three contexts influence adoption, but they have identified unique sets of factors or measures for each specific technology or context being studied. For example, Zhu et al. (2004) argue that "technology readiness" is a crucial factor in the technological context affecting the adoption of e-business. Similarly, "firm size," "global scope," and "financial resources" are key factors in understanding how the organizational context influences e-business adoption (Baker, 2011). Other scholars suggest that complexity and observability were not significant factors for Chinese SMEs in adopting digital innovations, whereas they were highly significant for Pakistani SMEs in adopting mobile payment systems (Khan et al., 2021). Notably, recent research by Nguyen et al. (2022) highlights top management support, entrepreneurial orientation, and technological orientation as significant factors positively influencing AI adoption. These results are also supported by scholars focusing on determinants of AI adoption within the enterprise environment (Dörr et al., 2023; Korherr et al., 2022), ultimately leading to improved processes and better performance, as shown in Figure 1 (Nguyen et al., 2022). Scholars have explored the critical factors for adopting IoT, AI, and cloud computing within organizations

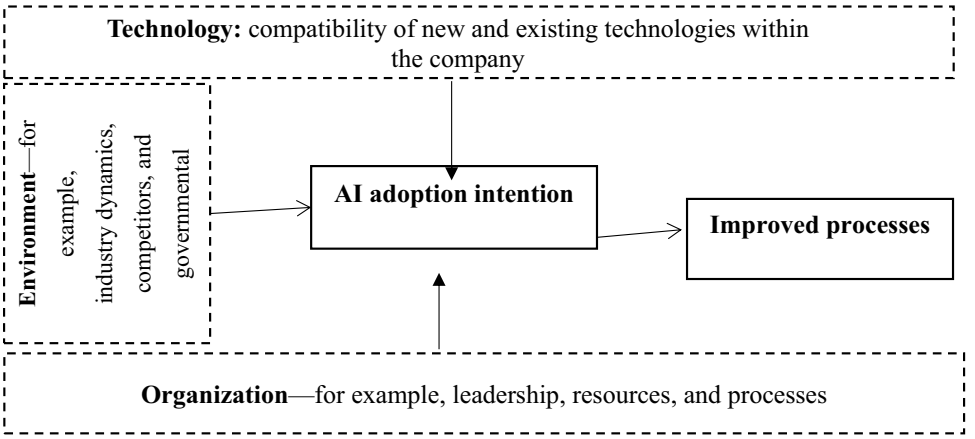

Figure 1. Technology–organization–environment model based on the conceptual model of Nguyen et al. (2022).

using the TOE model. They have discovered that technological factors, such as compatibility and uncertainty, are the primary influences for applying AI technologies, while organizational factors like company size appear to be less significant (Jang et al., 2022).

By structuring different clusters and integrating them into a theoretical foundation, the TOE model facilitates a comprehensive analysis of whether technologies are adaptable within an organization. Therefore, we contend that examining the influential factors within the three clusters—technology, organization, and environment—will provide scholars and practitioners with a comprehensive understanding of the current state of research on AI application in SMEs. This highlights the usefulness of the TOE model in comprehending and analyzing AI technology adoption by SMEs.

Methodology

The chosen research methodology, SLR, is known for its transparency, replicability, and structured overviewing of existing research (Tranfield et al., 2003). This approach is used to explore AI technology applications within SMEs. The SLR approach offers several benefits, including (1) reproducible steps for review validity and (2) comprehensive synthesis and analysis of accumulated knowledge (Kraus et al., 2023). Employing SLR to systematically map AI-related studies in SMEs provides a holistic understanding of AI technology applications within this domain in the literature (Kraus et al., 2022; Sauer & Seuring, 2023). Furthermore, scholars within the managerial field (a focus of this study) have proven that SLR is quite important (Kraus et al., 2023, 2024; Öztürk et al., 2024).

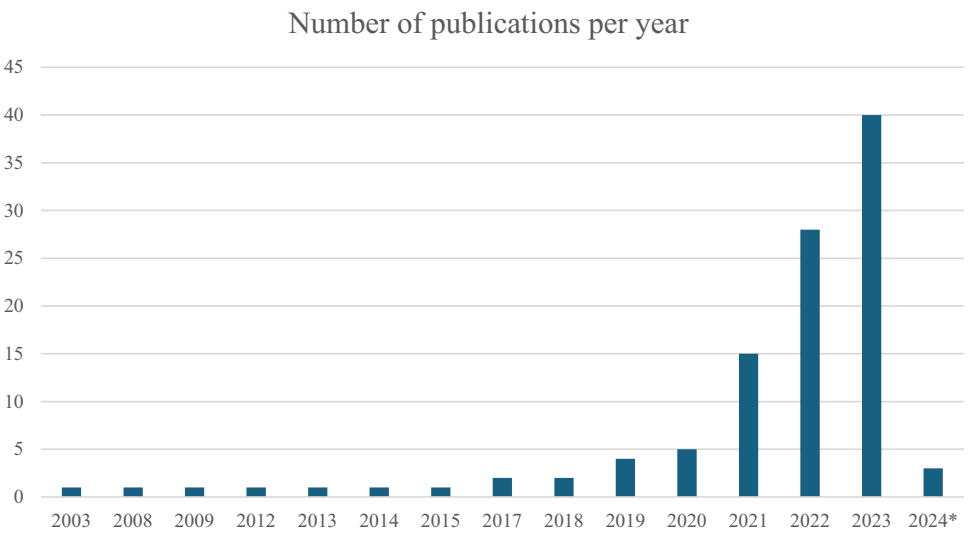

Figure 2. Publications included in the study by year of publication. *until June, 2024.

Search strategy

We employed EBSCO and Web of Science as the journal databases for our study because of the extensive body of literature they cover. Appendix A provides a table of their subdatabases, including their contributions to this study. Our focus was on the subject areas "artificial intelligence" and "SME." We conducted our searches using Boolean search terms in the title, abstract, and keywords sections. Specifically, we used the term "artificial intelligence" in conjunction with various other terms like "SMEs or small and medium-sized enterprises," "SME," and "small business." We employed diverse spellings and synonyms to encompass a broad range of possibilities, such as "artificial intelligence," "ai," "deep learning," and "machine learning." These feasible options resulted in the 36 search strings found in Appendix B, all of which were utilized. The period reviewed was before and including August 2023. We focused on peer-reviewed journal articles to ensure methodological rigor (Jones et al., 2011). In Figure 2, one can find the number of publications per year for the papers in the study.

Initially, our search yielded 12,548 articles. Details of the SLR process and the number of papers retained after each stage can be found in Figure 3. The material collection comprises only peer-to-peer-reviewed articles to obtain a comparable body of research. We included all peer-reviewed journals that were output by the research strings in German and English. The observed time frame is 2003 until June 2024, as AI began gaining importance for SMEs in the early 2000s. The search identified 768 articles in the EBSCO database for further analysis after eliminating

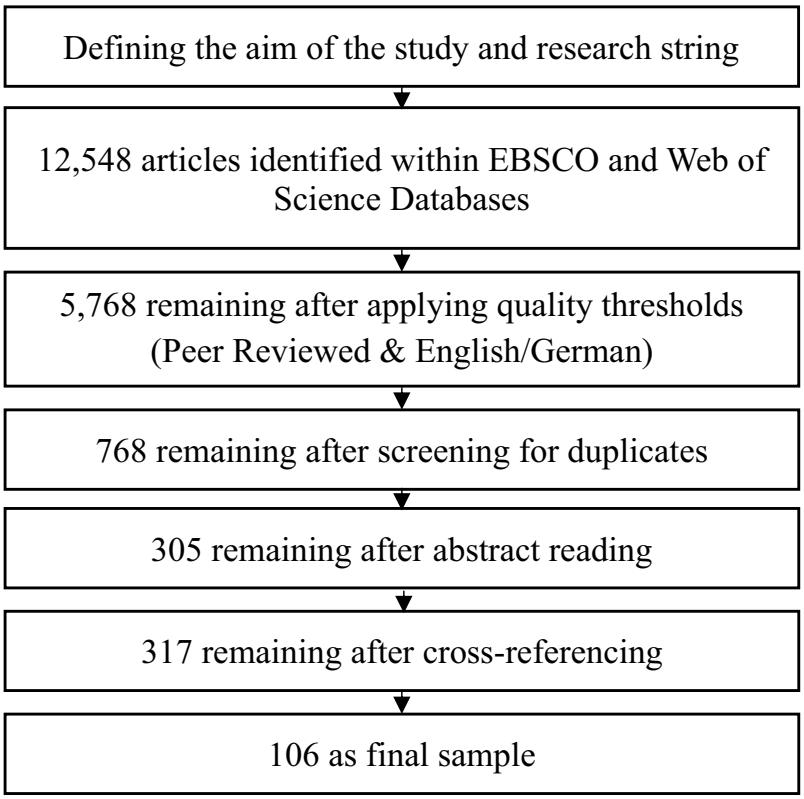

Figure 3. Selection process of the literature review according to Tranfield et al. (2003).

duplications (see Figure 3). Subsequently, we evaluated the quality of these remaining papers by reading their abstracts. Further exclusion criteria retained only articles linked to Artificial Intelligence and SMEs within a business context. Studies outside the business scope were discounted after reading the titles and abstracts. Considered out of scope was any research regarding the mathematical nature of AI and its IT components, as technical descriptions of the technologies do not answer the research questions. Non-peer-reviewed publications were also discounted. Further excluded were articles that did not explicitly analyze the application of AI technologies within SMEs, but rather within larger companies. Our study includes all industries identified in the contributions identified. This review process led us to identify 305 papers specifically centered on AI in SMEs. After reading the full texts of the remaining articles and applying the filter criteria, the final sample comprised 106 articles from the EBSCO and Web of Science databases.

We examined the identified studies based on the three clusters of the TOE model and assessed the influential factors within these clusters to

determine which factors are essential for SMEs to consider when adopting AI.

Results

The 106 articles in our SLR are categorized into eight distinct clusters, each representing a different aspect of the impact of AI on SMEs, as depicted in Table 1. The largest cluster, "Compatibility," with 19 contributions, discusses the importance of aligning old and new IT systems, strategies, and company values. The "Culture" cluster (19) explores attitudes toward innovation and technology adoption. The third-largest cluster, "Resources" (17), focuses on financial and personnel resources, leadership styles to mitigate scarce resources, and strategic utilization. The "Infrastructure" cluster, with 16 contributions, discusses SMEs' need to adopt AI, relying on existing IT infrastructure and a business-focused approach. The "Knowledge" cluster, with 10 contributions, emphasizes the significance of employees' expertise and knowledge, highlighting their role in successful technology transformation, knowledge exchange with global experts, digital proficiency, and their correlation with positive attitudes toward AI technologies. In the "Ecosystem" cluster (9), SMEs strategically collaborate with external organizations for research and development (R&D), leveraging diverse knowledge sources and external support to effectively integrate AI into their operations. In the "Competition" cluster (8), competitive pressures drive organizations to adopt AI technologies to enhance performance and gain a competitive advantage. The "Regulation" cluster (8) discusses AI regulation in SMEs, emphasizing the importance of strategic policies and government involvement with investments in training curricula crucial to equipping the workforce with digital skills. A list of the individual contributions analyzed in this study can be found in Appendix C.

Application of the technology–organization–environment model to our systematic literature review

Technology

The first enabler cluster within the TOE model consists of aspects of technology. Here we evaluate the compatibility of new and existing technology within the company's IT landscape (Nguyen et al., 2022).

Compatibility

Research indicates that the primary drivers for AI implementation originate from within the company. A key factor in successful adoption is compatibility, which involves aligning AI with the company's strategy and current IT landscape (Almeida & Wasim, 2023). Hansen and Bøgh (2021) highlight that

Table 1. Articles by cluster based on elaborations of the authors.

Cluster	Compatibility	Infrastructure	Knowledge	Resources	Culture	Competition	Regulation	Ecosystem
Number of Articles	19	16	10	17	19	8	8	9
Exemplar of Articles	Almeida and Wasim (2023) Chatterjee et al. (2022) Hansen and Bøgh (2021)	Barczak et al. (2019) Chowdhury et al. (2023) Delen et al. (2013)	Bagale et al. (2023) Choudrie et al. (2023) von Garrel and Jahn (2022)	Baabdullah et al. (2021) Dörr et al. (2023) Kraus et al. (2017)	Ballestar et al. (2021) Lu et al. (2022) Weber (2023)	Albats et al. (2020) Barata et al. (2023) Wang et al. (2022)	Boubaker et al. (2023) Dey et al. (2023) Hwang and Kim (2022)	Haddoud et al. (2023) Khan et al. (2021) Qu et al. (2021)

alignment with existing IT processes and the current IT strategy is crucial for AI adoption. In addition, integrating AI into the existing IT landscape provides competitive advantages like improved productivity and scalability (Hunter, 2019).

Ensuring smooth integration of new technologies is essential, especially for manufacturing SMEs, which often use machinery and production methods over extended periods. These companies need to avoid compatibility issues that could lead to additional adjustments, effort, and financial investment (Hansen & Bøgh, 2021). Therefore, when SMEs invest in new technologies, they prioritize ensuring these technologies work seamlessly with their existing systems. As AI integration advances, other factors gain significance. Some emphasize the strategic importance of technology road mapping for efficient AI application, noting that unplanned technology frameworks can impede AI adoption and advocating for a value-centric approach (Kim & Seo, 2023). Compatibility also encompasses work practices, needs, and company culture, which can influence AI adoption (Chatterjee et al., 2022). Perceived ease of use is critical for technology acceptance, and perceived usefulness, defined as the belief that using a system will enhance job performance, plays a significant role. When SME leaders believe AI can enhance performance, they are more likely to adopt it (Fatima & Bilal, 2019). Numerous studies have consistently shown that perceived usefulness positively influences the intention to use and implement AI (Escobar et al., 2023; Chatterjee et al., 2022).

Infrastructure within small and medium-sized enterprises

AI readiness in SMEs is intricately linked to their IT and technological infrastructures (Polas et al., 2022). AI technologies are highly integrated and interconnected, functioning systematically rather than in isolation. When implementing AI, SMEs must adopt a technical as well as a business-focused approach. Even though AI readiness focuses strongly on IT aspects, SMEs can survive, grow, and remain competitive by recognizing the strategic value of digital applications (Denicolai et al., 2021).

The importance of AI readiness might have financial implications for SMEs when not preparing the digital change. If AI readiness in terms of IT infrastructure is low, SMEs may perceive investments in AI as excessive and the technology as too difficult to manage (Chowdhury et al., 2023). Therefore, the ability of SMEs to adapt quickly to changes significantly influences their capacity to innovate and adopt new technologies like AI.

A holistic perspective ensures that AI integration aligns with organizational objectives, promoting seamless incorporation into existing processes (Polas et al., 2022).

Denning (2020) notes that in today's dynamic business landscape, the successful integration of AI hinges on delivering seamless and efficient IT processes.

Organization

The second enabler cluster focuses on organizational aspects within companies, such as knowledge, resources, and culture (Nguyen et al., 2022).

Knowledge

The human aspect, a key AI enabler in SMEs, involves employees' expertise and knowledge. Choudrie et al. (2023) emphasize the role of expertise in successful technology transformation and its impact on innovation diffusion. Knowledge exchange connects global experts (Łabędzka, 2021), highlighting employees' digital proficiency to apply new technologies. Expertise and knowledge lead to relative advantages and predict a positive attitude toward AI technologies (von Garrel & Jahn, 2022). If employees believe AI enhances their performance, they embrace it and perceive value in user-friendly AI. Willingness to change is vital because of new technology's uncertainties (Łabędzka, 2021). On top of that, efficient utilization of AI technologies equips human resources with essential information and skills, such as computer literacy, critical thinking, and effective decision-making (Grashof and Kopka (2023). By embracing advanced technologies and integrating AI strategically with human resources, SMEs can leverage the transformative potential of AI to gain a competitive advantage, foster innovation, and achieve sustainable growth (Choudrie et al., 2023). A human-centric approach is highlighted by Bagale et al. (2023), who demonstrate that perceived AI usefulness positively impacts digital transformation, demanding effectiveness, performance, trust, and risk management.

Resources

AI adoption faces challenges including finances, resistance, compatibility, complexity, and legal issues. SMEs may face challenges related to limited funds (Dörr et al., 2023). Not surprisingly, AI adoption in SMEs is often influenced by financial and personnel resources, which can either support or hinder its implementation (Kraus et al., 2017). SMEs may face hindrances due to poor technical expertise, inadequate skills, or improper management styles due to limited AI education (Liu, 2023). Furthermore, the lack of AI specialists limits the potential for AI in SMEs (Lemos et al., 2022). Challenges also arise from the feasibility of overhauling systems and processes, limited access to resources for implementing technology, high risks associated with technology adoption, and concerns about its effectiveness (Baabdullah et al., 2021). Limited funds impact SMEs' AI investment (Venkateswarlu et al., 2022), hampering cost-effectiveness (Khan et al., 2023). In addition, with limited financial resources, SMEs often acknowledge the benefits of AI systems but fear the associated costs (Dörr et al., 2023). Smaller enterprises, however, benefit from streamlined communication and fewer management levels,

allowing direct management involvement in R&D (Sousa & Wilks, 2018). This direct involvement minimizes the risk of miscommunication between technical personnel and senior management, fostering agile decision-making processes. Capacity issues arise from limited funds, impacting research and networks. However, despite perceiving resource constraints as a barrier, SMEs possess a greater awareness of environmental needs, leading to a higher intention to innovate (Rojas-Córdova et al., 2020). The agile and adaptable nature of SMEs, coupled with their direct leadership involvement, presents advantages in implementing AI. Although resource limitations may exist, SMEs' responsiveness to environmental demands drives their determination to innovate and embrace transformative technologies.

Culture

Within SMEs, the integration of AI presents several challenges, with organizational culture emerging as a pivotal factor. Delving into the organizational culture cluster, one might explore how SMEs that have embraced AI undergo a profound transformation in their cultural fabric (bin Ahmad et al., 2019). This reshaping of processes and business paradigms brought about by AI profoundly influences a firm's culture.

Research indicates that this cultural facet can be dissected into three distinct components. First, fostering a learning culture involves honing the workforce's AI-related skills and capabilities through shared learning spaces, enabling mutual knowledge exchange and constructive feedback. This learning readiness within the workforce enhances the organization's agility in assimilating new technologies, thereby bolstering sustainable growth. Simultaneously, the exigency for ongoing skill acquisition on individual and organizational levels becomes apparent. This readiness hinges on adept IT resources and well-prepared employees poised to seamlessly adopt innovative technologies (Khan et al., 2022). Comprehensive education and practical training empower SME workers, allaying apprehensions and facilitating perceived ease of use (Hamdan et al., 2022).

Communication constitutes the second facet of organizational culture pertinent to AI implementation. Open dialogue with stakeholders and employees is vital for acclimatizing them to the constant flux accompanying AI integration (Khan et al., 2022). A learning organization ethos, marked by a willingness to embrace change and learn from errors, is fundamental for AI adoption in SMEs (Kucharska & Bedford, 2020). The embrace of mistakes is intrinsic to this culture, catalyzing growth underscored by adept managerial support.

This brings us to the third dimension of organizational culture—leadership style and management commitment in the context of AI. Top-tier management's unwavering support proves to be important in the successful assimilation of new technologies. The fluidity of leadership styles is imperative,

mirroring AI's propensity to reshape business models, necessitating the ability to unfreeze, freeze, and refreeze resources in alignment with congenial strategies (Khan et al., 2022). Leadership plays a strong role in the dynamic capabilities of firms through the ongoing development of new practices (Quansah & Hartz, 2022). Quansah et al. (2021) observed that adaptive SME leaders engage key stakeholders in knowledge development and deployment to survive uncertainty. Notably, leadership roles demand adaptability and problem-solving prowess and by investing in workforce development, firms gain a competitive edge. The intricate interplay between AI integration and organizational culture within SMEs is a multifaceted endeavor. A proactive learning culture, continuous skills development, transparent communication, and adaptable leadership collectively shape a fertile ground for SMEs to seamlessly integrate AI and forge a path toward sustainable progress.

Environment

The third enabler cluster focuses on external factors, such as competitors, governmental regulations, and ecosystems (Nguyen et al., 2022).

Competition

External competitive pressures can influence the adoption of AI in an organization. If competing organizations perform more effectively, other organizations are pressured to compete as well. With increasing competitive pressure, organizations can use emerging technologies to gain a competitive advantage (Chaudhuri et al., 2022). The increasing opportunity to obtain a higher service orientation with AI, as well as to develop new business models and open up new markets, are further relevant factors (Merkel-Kiss & von Garrel, 2022). Experts and expert communities played a key role across different stages of the SMEs' innovation process (Albats et al., 2020).

Regulation

The regulation of AI in SMEs necessitates strategic policies and government involvement to ensure their successful integration. As AI's significance continues to grow, investing in training curricula becomes paramount to equip the workforce with essential digital skills for the future (World Economic Forum, 2020). Given the crucial role of SMEs on national and global levels, understanding their performance and efficiency is vital for effective policy-making (Boubaker et al., 2023). However, SMEs face a challenge in embracing digital transformation without a positive return on investment (ROI) (Hwang & Kim, 2022). Effective policies and government support must address these challenges, offering incentives, and guidance to facilitate AI adoption in SMEs, ensuring their competitiveness and sustainable growth in the global economy (Dey et al., 2023).

Ecosystem

SMEs strategically employ various approaches to harness the potential of AI in their operations. One key approach is collaborating within their ecosystem. Due to limited innovative resources and capabilities, SMEs often partner with external organizations for collaborative R&D (Qu et al., 2021). This collaboration is vital for several reasons. For instance, it allows SMEs to bypass the significant internal investment of time and resources required to develop technological capabilities, thereby focusing on new product development (Tsai & Wang, 2008). In addition, collaborations between SMEs and industrial partners using machine learning-based decisions result in high satisfaction rates when R&D expenditure and research intensity are high (Jun et al., 2021).

Haddoud et al. (2023) demonstrate that collaborative practices in AI applications help SMEs overcome institutional voids, facilitating the successful development of innovative products and enhancing their access to export markets. This collaborative innovation provides access to diverse knowledge, aiding AI implementation and technology integration. Moreover, SMEs leverage external support to foster innovation, with networks serving as key sources of innovation (Hermawati & Gunawan, 2021).

Collaborative AI activities with external partners and universities enable SMEs to explore operational opportunities and achieve international growth (Haddoud et al., 2023). Furthermore, better access to customers can leverage the potential of AI. By using AI technologies, SMEs can work closely with customers and obtain first-hand feedback (Hermawati & Gunawan, 2021). AI tools can quickly gather customer feedback cost-efficiently, though they have weaknesses such as lower accuracy, distortion, low user seriousness, and less structured data (Mount & Martinez, 2014).

By strategically employing these approaches, SMEs effectively integrate AI into their operations, driving innovation and securing competitive advantages in today's dynamic business landscape.

Improved processes and better performance

Research has demonstrated that the application of AI offers numerous benefits for SMEs when well-integrated into the existing IT landscape. Scholars have investigated various use cases and business functions where AI can be effectively applied, such as risk management, human resources, and marketing. For instance, AI can predict credit risks, thereby lowering costs and enhancing decision-making processes (Jutasompakorn et al., 2023).

In marketing, AI provides innovative AR experiences that significantly improve customer satisfaction (Sousa & Wilks, 2018). It also allows firms to gather first-hand customer feedback cost-efficiently, despite potential weaknesses in accuracy and structure (Mount & Martinez, 2014). In addition, AI enhances customer experiences and loyalty by supporting supply chain and

sustainable practices (Liu, 2023). AI tools improve decision-making and insights, contributing to better customer satisfaction (Babucea & Rabontu, 2022; Rizomyliotis et al., 2022). Furthermore, AI in e-commerce boosts market share, efficiency, profitability, and customer satisfaction by providing faster product information and behavior analysis (Fonseka et al., 2022b).

In the realm of human resources, AI supports administrative tasks and personnel searches, addressing challenges related to employment and education (Weber, 2023). The involvement of top managers in AI initiatives facilitates the implementation of action plans, including human resources training and communication of AI benefits (Baabdullah et al., 2021).

AI analysis tools play a crucial role in enhancing resource efficiency, reducing costs, and providing extra value for companies (Chaudhuri et al., 2022). In particular, AI enhances efficiency in automating processes, creating innovative insights, engaging with stakeholders, and providing an improved customer experience (Zhang et al., 2021). Despite these benefits, challenges persist, such as identifying suitable processes and achieving team acceptance (Andrade, 2020; Beerbaum, 2021; Carraro, 2021; Hindel et al., 2020; Hofmann et al., 2020; Ribeiro et al., 2021; Turcu & Turcu, 2021). In addition, AI can only be adopted efficiently throughout the organization with the commitment of senior management, making that commitment crucial in enabling technological ecosystems through AI adaptation initiatives (Lemos et al., 2022).

Discussion

We crossed our eight thematic clusters with the three dimensions of the TOE model to highlight the most relevant emerging areas, as shown in Figure 4. The discussion surrounding the advantages and disadvantages inherent in AI integration underscores the multifaceted nature of this process. While AI promises significant benefits in terms of efficiency, accuracy, and customer satisfaction across various domains, it also poses challenges such as financial constraints, resistance, compatibility issues, and legal and technical complexities. Implementing and using AI unequivocally leads to an increase in enterprise innovation (Barczak et al., 2019). AI technologies, distinguished by their integrated and connected characteristics, operate systematically rather than in isolation, shaping their seamless incorporation within the SME ecosystem (Hwang & Kim, 2022). For SMEs, implementing transformative technologies like AI necessitates a business-focused approach surpassing mere IT considerations (Denicolai et al., 2021). This holistic perspective ensures alignment with organizational objectives and that AI's integration augments existing processes. Our findings indicate that implementing AI leads to process improvements due to improved customer communication and efficient handling of data, which aligns with the TOE model. AI enables SMEs to reach wider customer bases, optimize profits, and save resources (Chaudhuri et al., 2022;

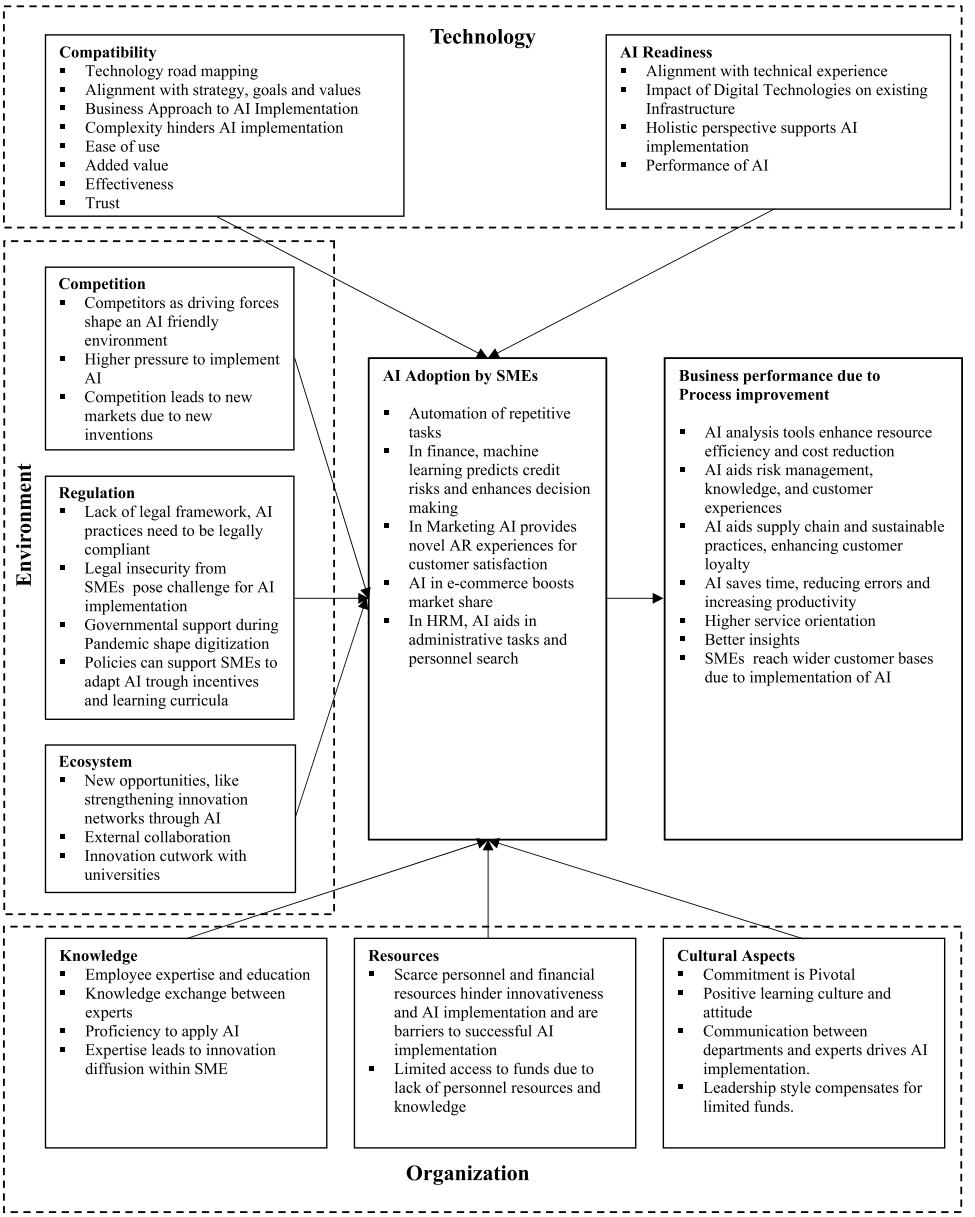

Figure 4. Clustered findings in the TOE model (elaboration by the authors).

Christen et al., 2022). Moreover, the pivotal role of a positive ROI emerges as a decisive factor in determining the feasibility of AI adoption, emphasizing the need for a thorough understanding of its potential benefits and costs. Our examination reveals that the adoption of AI in SMEs is characterized by facilitators and impediments, shaping the trajectory of its integration. However, the mapping of these clusters with the TOE model underscores

nuanced gaps, particularly in the environmental aspect. Governmental policies play a pivotal role in influencing SMEs' digital transformation efforts, necessitating supportive frameworks to overcome financial constraints associated with AI implementation (Siahaan & Tan, 2022). Furthermore, external competitive pressures drive AI adoption as organizations seek to gain a competitive edge through enhanced customer anticipation and data management capabilities (Chaudhuri et al., 2022). Despite acknowledging the importance of resource allocation and positive ROI, challenges such as financial constraints, resistance, compatibility issues, and legal complexities persist in the adoption journey (Hwang & Kim, 2022; Kraus et al., 2017; Merkel-Kiss & von Garrel, 2022). Moreover, the issue of legal uncertainties surrounding AI adoption in SMEs underscores the need for comprehensive frameworks to provide guidance for navigating regulatory landscapes (Merkel-Kiss & von Garrel, 2022).

Similarly, the observability dimension underscores the necessity of visible perceived value to drive AI adoption, emphasizing effectiveness, performance, trustworthiness, and risk mitigation (Chatterjee et al., 2022; Nguyen et al., 2022).

While limited resources are seen as one of the most hindering factors, management commitment can compensate for that negative, as it strengthens communication between experts, driving an innovative and progressive mindset within the company (Rojas-Córdova et al., 2020). Hence, senior management commitment emerges as a critical determinant in fostering AI integration initiatives, facilitating action plan implementation, and overcoming organizational challenges (Lemos et al., 2022). In addition, firm size influences AI adoption dynamics, with smaller enterprises leveraging streamlined communication channels and heightened innovation intentions (Qu et al., 2021; Rojas-Córdova et al., 2020).

Entrepreneurial orientation further shapes SMEs' approach to technological adoption, with a balance between risk-taking and effective risk-management practices driving innovation efforts (Kemendi et al., 2022, Schwertner, 2017; Miller, 1983). The holistic integration of AI technologies within SME ecosystems underscores its transformative potential, driving process improvements, enhanced customer experiences, and sustainable practices (Christen et al., 2022; Denicolai et al., 2021; Hwang & Kim, 2022; Liu, 2023; Merkel-Kiss & von Garrel, 2022; Rizomyliotis et al., 2022).

In summary, our findings contribute to a nuanced understanding of AI adoption in SMEs, emphasizing the need for interdisciplinary approaches and targeted interventions to maximize its potential benefits while mitigating the associated challenges.

Theoretical implications

The ongoing trend of technology development will result in AI being of relevance to academia for a long time, as with technology, the needs and drivers of AI might change. In addition, as the majority of companies globally fit into the SME segment, a large sample size will be available when conducting research (Organization for Economic Co-operation and Development, 2020). Our study contributes to the existing literature by synthesizing research findings within a theoretical framework and identifying emerging areas for future research. It emphasizes the multidimensional nature of AI adoption in SMEs and underscores the importance of considering environmental, technological, and organizational factors in facilitating successful implementation. By leveraging the TOE framework, researchers can gain a deeper understanding of the enablers and barriers to AI adoption and identify research fields for fostering a culture of innovation and technological advancement within SMEs. In addition, researchers can gain an understanding of the interdependencies between identified clusters. Furthermore, the research ideas proposed will fill existing research gaps and hence facilitate more research opportunities for other researchers and might even enhance classroom discussions. Our study represents a comprehensive examination of this subject matter through a structured literature review, making it a valuable addition to the landscape of scientific research. By mapping our findings to the TOE model, a predictor for successfully implementing AI in SMEs, we highlight areas where existing literature provides substantial insights and areas where further research is required. This approach ensures that future research within this domain can be more precise.

Managerial relevance

Our systematic literature analysis reveals that AI adoption in SMEs can positively impact business when new technologies align with existing practices. Decision-makers should foster a learning culture, invest in the workforce, engage in transparent communication, and practice adaptable leadership. To implement AI successfully, a robust legal framework is essential to guide decision-makers. SMEs must address challenges like limited resources, resistance, and compatibility. By acquiring necessary skills, effectively managing, and assessing AI's benefits, SMEs can overcome these challenges and harness AI's power.

In the evolving business landscape, SMEs should leverage their size and agility. Streamlined communication, innovation readiness, and leadership involvement enhance adaptability to AI-driven changes, driving innovation and competitive advantage. Our findings highlight the crucial role of external factors, such as governmental policies and competitive pressures, in shaping

the AI adoption landscape for SMEs. Supportive policies are needed to mitigate financial constraints and foster an environment conducive to AI implementation, underscoring policymakers' role in facilitating technological advancement within the SME sector.

SMEs' AI readiness depends on IT infrastructure and strategic integration with HR. Aligning AI with existing practices, addressing challenges, and considering customer needs enhance adoption success. AI can help SMEs optimize profits, reach broader customer bases, and improve efficiency. Overcoming challenges and addressing AI specialist shortages are vital for SME transformation. Understanding and addressing these challenges enable SMEs to harness AI's potential and thrive in the digital era.

Researching the integration of AI in SMEs is highly relevant, as it can significantly impact a firm's competitive position within its industry (Giuggioli & Pellegrini, 2023). Decisions made by management today regarding AI adoption will have far-reaching implications for these enterprises' futures. Our study builds on the existing body of knowledge by emphasizing the significance of AI for SMEs and elucidating the key enablers, barriers, organizational structures, and technological and human resources essential for successful AI implementation. Researching AI adoption in SMEs is crucial, as it can be a lever for a company's success within its segment.

Future research and limitations

Three areas for further research are particularly compelling. First, researchers often analyze SMEs' AI adoption in isolation, focusing on how different aspects independently affect performance outcomes. However, it is essential to consider potential interactions, including compensating and synergistic effects, among these interdependent factors. Future research should explore how diverse facets of AI adoption across various functional domains such as marketing, networking, and technology collectively influence SME performance (Albats et al., 2023). This research should delve deeper into digitalization strategies within SMEs, ensuring that AI fits well with existing practices, recognizing challenges, and developing KPI frameworks for assessing AI implementation. Second, researchers should focus on country-specific phenomena in SME adoption of AI. Local factors, such as regulatory frameworks, cultural nuances, government incentives, and economic conditions, significantly influence AI implementation. Investigating how these factors shape the strategies and outcomes of AI use by SMEs in different countries can provide valuable insights for tailoring AI adoption strategies and policies to the unique characteristics of SMEs in diverse global contexts (Boubaker et al., 2023). Third, research should examine AI adoption and impact within various SME contexts, such as founder- and family owned enterprises (Worek & Aaltonen, 2023) and women- and minority-owned enterprises (Mendonça de Lima et al.,

2023). These distinct ownership structures and demographics can introduce unique dynamics and challenges to AI integration. Investigating how AI adoption strategies, barriers, and outcomes differ among these SME categories can enhance understanding of tailored approaches for maximizing AI's benefits while addressing the specific constraints and opportunities associated with each ownership or demographic profile.

This study has two principal limitations. First, it exclusively encompasses published peer-reviewed papers. This narrow focus raises the possibility of publication bias, wherein studies with statistically significant results tend to receive preferential publication over those with nonsignificant results (Egger et al., 2001). Consequently, it is prudent to exercise caution when extrapolating our findings to broader contexts. Second, although we have exclusively reported on capabilities that have received the highest frequency of research attention, it nevertheless remains plausible that these capabilities may not necessarily possess the strongest correlation with performance outcomes. To discern which capabilities exhibit the most robust relationships with performance, we encourage further research endeavors, such as meta-analyses dedicated to each category of capability.

Conclusion

The integration of AI within SMEs is a multifaceted endeavor influenced by various enablers and barriers along technological, organizational, and environmental dimensions. The exploration of literature regarding AI's impact on SMEs underscores its potential to enhance efficiency, competitiveness, customer experience, and sustainability across domains such as finance, marketing, and human resource management (Hansen & Bøgh, 2021).

The TOE model is a robust framework for understanding the factors driving AI adoption in SMEs. Our findings align with this model, demonstrating the significance of factors like technology compatibility, organizational culture, senior management commitment, innovation perception, and risk-taking propensity, but also show that some dimensions are underrepresented in the literature (Nguyen et al., 2022). These blind spots include trend identification and legal requirements for AI implementation, noting that academia calls for clear policies through legal requirements.

Overall, this research increases the understanding of the complex interplay between AI adoption and SMEs, offering valuable insights into how SMEs navigate the dynamic landscape of technological innovation. AI technologies present SMEs with a plethora of opportunities to optimize profits, reach a broader customer base, and improve efficiency and competitive advantage (Hansen & Bøgh, 2021). This research aligns existing literature with the operational TOE model and underscores that successful AI adoption depends on aligning existing practices and cultures and addressing customer needs while simultaneously considering potential challenges, including financing,

resistance, compatibility, complexity, and legal issues. Compatibility spans across work methodologies, necessities, and cultural aspects, exerting an influence on AI integration (Chatterjee et al., 2022). When AI aligns with the specific needs and innovation objectives of SMEs, the likelihood of their enthusiastic adoption increases. By embracing AI-driven efficiency improvements, SMEs can enhance customer experiences, foster sustainable practices, and position themselves at the forefront of digital transformation. AI adoption by SMEs faces challenges and barriers ranging from financial constraints and internal resistance to organizational complexity and legal considerations (Venkateswarlu et al., 2022). To foster successful AI implementation, SMEs must recognize and address these challenges. Furthermore, addressing the scarcity of AI specialists is crucial to maximizing the benefits of AI technologies in SMEs. Understanding and overcoming these challenges is essential if SMEs are to harness the transformative potential of AI and thrive in this dynamic digital era. Aspects such as a learning culture and openness toward AI are part of the organizational dimension, and it should be noted that a positive culture and therefore a welcoming attitude toward new technology will improve the likelihood of AI adoption within SMEs.

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No potential conflict of interest was reported by the authors.

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Appendices

Appendix A. Databases

Database	Number of Articles
Academic Search Index	1
Business Source Ultimate	26
Complementary Index	26
ECONIS	3
Emerald Insight	13
MEDLINE	2
ScienceDirect	21
Springer Nature Journals	14
	106

Appendix B. Consolidated search results from EBSCO and Web of Science

Number	Search Term I	Search Term II	Field	Number of Results	Peer Reviewed and English
1.	artificial intelligence	smes or small and medium-sized enterprises	Title	4	3
2.	artificial intelligence	smes or small and medium-sized enterprises	Subject Term	6	6
3.	artificial intelligence	smes or small and medium-sized enterprises	Abstract	180	147
4.	artificial intelligence	sme	Title	144	99
5.	artificial intelligence	sme	Subject Term	60	51
6.	artificial intelligence	sme	Abstract	648	378
7.	artificial intelligence	small business	Title	82	6
8.	artificial intelligence	small business	Subject Term	976	381
9.	artificial intelligence	small business	Abstract	1,322	738
10.	ai	smes	Title	339	75
11.	ai	smes	Subject Term	33	18
12.	ai	smes	Abstract	984	465
13.	ai	sme	Title	339	75
14.	ai	sme	Subject Term	33	18
15.	ai	sme	Abstract	726	441
16.	ai	small business	Title	498	18
17.	ai	small business	Subject Term	15	6
18.	ai	small business	Abstract	1,572	501
19.	deep learning	smes or small and medium-sized enterprises	Title	0	0
20.	deep learning	smes or small and medium-sized enterprises	Subject Term	0	0
21.	deep learning	smes or small and medium-sized enterprises	Abstract	93	63
22.	deep learning	sme	Title	3	3
23.	deep learning	sme	Subject Term	6	0
24.	deep learning	sme	Abstract	219	171
25.	deep learning	small business	Title	6	3
26.	deep learning	small business	Subject Term	60	51
27.	deep learning	small business	Abstract	561	351
28.	machine learning	smes or small and medium-sized enterprises	Title	3	3
29.	machine learning	smes or small and medium-sized enterprises	Subject Term	6	0
30.	machine learning	smes or small and medium-sized enterprises	Abstract	288	210
31.	machine learning	sme	Title	144	114
32.	machine learning	sme	Subject Term	42	24
33.	machine learning	sme	Abstract	729	254
34.	machine learning	small business	Title	75	9
35.	machine learning	small business	Subject Term	654	201
36.	machine learning	small business	Abstract	1,698	885
				12,548	**5,768**

Appendix C. Articles by cluster based on elaborations of the authors

Compatibility	Infrastructure	Knowledge	Resources
Almeida and Wasim (2023)	Albats et al. (2023)	Bagale et al. (2023)	Abualsauod (2023)
Babucea and Rabontu (2022)	Barczak et al. (2019)	Choudrie et al. (2023)	Baabdullah et al. (2021)
Camacho-Miñano et al. (2015)	Barton and Thomas (2009)	Christen et al. (2022)	Bettoni et al. (2021)
Chatterjee et al. (2022)	Chowdhury et al. (2023)	Grashof and Kopka (2023)	Das and Bala (2023)
Cho and Ju (2023)	Dabić et al. (2023)	Huin et al. (2003)	Dörr et al. (2023)
Drydakis (2022)	Dedhia (2021)	Łabędzka (2021)	Faqihi and Miah (2023)
Escobar et al. (2023)	Delen et al. (2013)	Lv et al. (2018)	Guebitz et al. (2012)
Fatima and Bilal (2019)	Denicolai et al. (2021)	Ma et al. (2023)	Khan et al. (2023)
Hansen and Bøgh (2021)	Denning (2020)	von Garrel and Jahn (2022)	Kraus et al. (2017)
Hoang and Bui (2023)	Hervás-Oliver et al. (2021)	Zaušková et al. (2022)	Lemos et al. (2022)
Hunter (2019)	Ichim Somogyi (2020)		Liu (2023)
Jutasompakorn et al. (2023)	Jüngling et al. (2022)		Rao et al. (2023)
Kim and Seo (2023)	Polas et al. (2022)		Rawashdeh et al. (2023)
Nagy et al. (2023)	Polisetty et al. (2023)		Rojas-Córdova et al. (2020)
Pelekamoyo and Libati (2023)	Savadogo and Stonis (2023)		Sousa and Wilks (2018)
Salmen (2022)	Siahaan and Tan (2022)		Venkateswarlu et al. (2022)
Sarwar et al. (2023)			Zhang et al. (2022)
Schönberger (2023)			
Teerasoponpong and Sopadang (2022)			

Culture	Competition	Regulation	Ecosystem
Abrokwah-Larbi (2024)	Albats et al. (2020)	Boubaker et al. (2023)	Haddoud et al. (2023)
Abrokwah-Larbi and Awuku-Larbi (2024)	Barata et al. (2023)	Chen et al. (2021)	Hermawati and Gunawan (2021)
Ballestar et al. (2021)	Calheiros-Lobo et al. (2023)	Dey et al. (2023)	Jun et al. (2021)
bin Ahmad et al. (2019)	Chaudhuri et al. (2022)	Hwang and Kim (2022)	Khan et al. (2021)
Calabrese et al. (2023)	Fonseka et al. (2022a)	Mancheva (2021)	Koppel and Tšernikova (2023)
Giuggioli and Pellegrini (2023)	Merkel-Kiss and von Garrel (2022)	Pošćić and Martinović (2022)	Mount and Martinez (2014)
Hamdan et al. (2022)	Rizomyliotis et al. (2022)	Truby et al. (2022)	Qu et al. (2021)
Ipinnaiye et al. (2017)	Wang et al. (2022)	K.-L. Wang et al. (2023)	Ragab et al. (2023)
Kemendi et al. (2022)			Tsai and Wang (2008)
Khan et al. (2022)			
Kucharska and Bedford (2020)			
Lu et al. (2022)			
Lu et al. (2024)			
Merhi and Harfouche (2023)			
Njoku et al. (2023) Quansah and Hartz (2022) Quansah et al. (2021)			
Rikhardsson et al. (2022)			
Weber (2023)			